This document is published in:

Novais, P. et al. (eds.) (2011). *Ambient Intelligence - Software and Applications: 2nd International Symposium on Ambient Intelligence (ISAmI 2011)*. (Advances in Intelligent and Soft Computing, 92). Springer, 117-124.
DOI: http://dx.doi.org/10.1007/978-3-642-19937-0_15

The EducAgent Platform: Intelligent Conversational Agents for E-Learning Applications

David Griol, Jesús García-Herrero, and José M. Molina

Group of Applied Artificial Intelligence (GIAA), Computer Science Department,
Carlos III University of Madrid
e-mail: {david.griol,jesus.garcia,josemanuel.molina}@uc3m.es

Abstract. In this paper, we describe a multi-agent system developed for teaching support and student's self-learning. The main objective of the *EducAgent* platform is the creation of an innovative virtual space following the principles of the European Higher Education Area to make subjects and e-learning initiatives to become a more flexible, participatory and attractive space. One of the most important characteristics of the developed platform is to facilitate a more natural interaction between the system and students by means of conversational agents. We describe the main features of the *EducAgent* platform and its application in the new European Computer Science Degree at the Carlos III University of Madrid.

Keywords: Conversational Agents, E-Learning, Oral Interaction, Intelligent Agents, Education and New Technologies.

1 Introduction

Ambient Intelligence (AmI) emphasizes on greater user-friendliness, more efficient services support, user-empowerment, and support for human interactions. In this vision, people will be surrounded by intelligent and intuitive interfaces embedded in everyday objects around us and an environment recognizing and responding to the presence of individuals in an invisible way [1]. To ensure such a natural and intelligent interaction, it is necessary to provide an effective, easy, safe and transparent interaction between the user and the system. This way, conversational agents [6], which marry agent capabilities with computational linguistics, have became a strong alternative to enhance multi-agent systems with intelligent communicative capabilities, as speech is one the most natural and flexible means of communication among humans.

With the growing maturity of conversational technologies, the possibilities for integrating conversation and discourse in e-learning are receiving greater attention, including tutoring [7], question-answering [9], conversation practice for language learners [3], pedagogical agents and learning companions [2], and dialogs to promote reflection and metacognitive skills [5].

In addition, learning and training institutions are growingly facing important challenges. In fact, the new framework of the European Higher Education Area (EHEA) involves teaching mainly oriented to the attainment of competencies, so that the role of the teacher is to facilitate and guide students to intellectually access contents and professional practices corresponding to their degrees. To achieve this objective, more participatory and reflective teaching methodologies are required to allow students reaching the maximum autonomous academic and personal development as possible. In this space, teachers are not only transmitters of knowledge, but also become professionals who create and organize complex learning environments, involving students in their own learning process by means of appropriate strategies.

In this framework, according to Roda et al. [8], enhanced e-learning systems are expected to i) accelerate the learning process, ii) facilitate access, iii) personalize the learning process, and iv) supply a richer learning environment. To do this, and promoted by the introduction of the new European degrees at Carlos III University of Madrid, continuous assessment has been introduced based on students' effort and active participation in their learning. This way, students are followed up through activities which promote their participation and knowledge acquisition, such as initiatives which enable them to know their progresses.

Following these premises to provide enhanced e-learning initiatives in the EHEA framework, we have developed the *EducAgent* platform. The main objective is to develop a flexible learning tool to offer the stimulus, support and environment necessary to guide students in a continuous and active learning process. To do this, intelligent conversational agents have been included in the architecture of our platform, which facilitate a more natural interaction between the system and students, select the different contents, present them to students, collect their answers, and provide a feedback after the analysis.

2 The *EducAgent* Platform

The *EducAgent* platform consists of a set of intelligent agents which works as a virtual space where students can interact to be presented cases and problems to be solved, which are adapted to their progresses and takes into account specific problems detected during the student's evolution during the course. In addition, student's interaction with the platform also allow to automatically assess their learning. To do this, we bring to our teaching the most recent advances made by the members of the project in different research fields.

Three main features are highlighted to be present in most of the educational intelligent agents. Firstly, the ability of *communication*. Intelligent agents can

communicate with the user, other agents and other programs. The user communicates with a user-friendly interface to customize their preferences. For the development of the *EducAgent* platform, we have defined communication with students in the most natural way possible as a priority. For this reason, the communication in our platform is carried out by means of advanced conversational agents. To successfully manage the interaction with users, conversational agents are usually developed following a modular architecture, which generally includes the following tasks: automatic speech recognition (ASR), natural language understanding (NLU), dialog management (DM), database management (DB), natural language generation (NLG) and text-to-speech synthesis (TTS). The development of these agents implies the achievement of a set of challenges, which depend on the selected languages models, dialog initiatives, confirmation strategies, responses generation, etc. Our proposal is the incorporation of statistical methodologies to deal with all these important design decisions [4].

The second main feature is the degree of *intelligence*, which has a wide range of possibilities often achieved by means of the incorporation of technologies from Artificial Intelligence. In our case, Speech Technologies and Natural Language Processing are used to facilitate the automatic analysis of students' responses. Finally, the third main feature is *autonomy*. An agent must not only be able to make suggestions, but also to act with proactiveness. In *EducAgent*, agents are implemented with the autonomy required to select which are the most appropriate contents to be presented to students and which is the most appropriate response that must be given as a result of the analysis of the interaction. Different natural language e-learning applications also offering learning reinforcement to review self-assessments are detailed in [5].

2.1 Architecture of the EducAgent Platform

Figure 1 shows the architecture designed for the EducAgent platform to select the different contents and generate a questionnaire, perform the interaction with students by means of a conversational agent, carry out the corresponding analysis of the students' answers, and provide them with the appropriate feedback.

As Figure 1 shows, for each one the units that make up the course, the platform selects from a database the different questions corresponding to the concepts selected for the evaluation and presents. The generated questionnaire is presented to the student using the Moodle platform and by means of the Opera browser. This way, students access the questionnaire on the web, and they can answer the questions using their voice, keyboard and/or mouse. To do so, these questionnaires are developed using the VoiceXML standard[1].

To allow students answering the different questions using their voice, the platform uses the ViaVoice speech recognition technology from IBM, embedded in the Opera browser. Once the text transcription of the speech has been obtained, the Language Understanding Module generates the semantic interpretation of the input

[1] http://www.w3.org/TR/voicexml20/

sentence. To do this, this module analyzes the contents provided by the students by means of specific grammars generated for each one of the questions. By obtaining the meaning of the student's utterance and using the result of its comparison with the correct answer defined by the teacher (contained in the database system and accessible by means of the database query module), the User Answer Analyzer calculates the percentage of success and the set of recommendations to be made to the student. This is done by means of grammars in which the student's answer is compared with the reference answer, assigning a specific score and answer each time a coincidence is detected. This way, in our system we provide a balance between accuracy and flexibility in the evaluation process. Test questions provide total reliability on the correction of these answers, while our grammar-based functionality offers the flexibility of natural language.

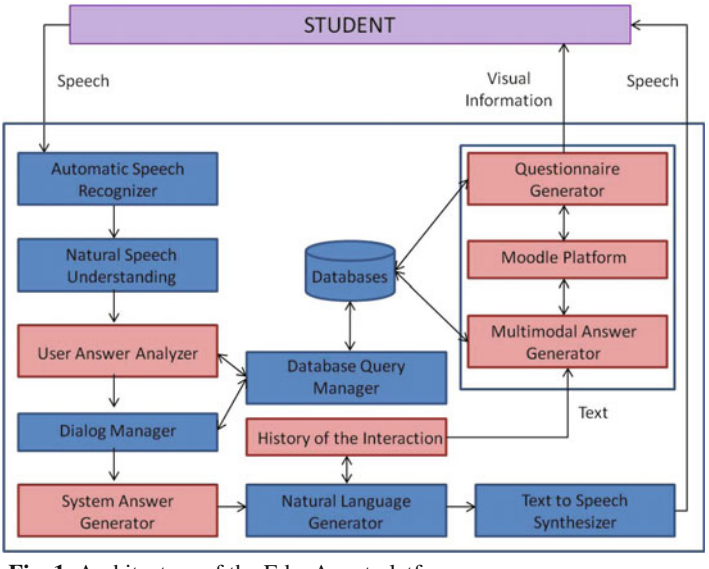

Fig. 1 Architecture of the EducAgent platform

Then, the Dialog Manager decides the next action of the platform, taking into account the analysis previously described for the utter utterance (for instance, to confirm information supplied by the student, to request additional information, to continue with the next question, etc.). The System Answer Generator takes into account the result of the analysis carried out for the previous set of system questions and generates the corresponding system answer, which is presented to the student by means of the result generated by the Natural Language Generation module. The generated text is formatted into VoiceXML code, which is presented using the Moodle platform, and by means of a synthesized voice that generates the oral answer corresponding to the generated answer.

This way, students can carry out several interactions with the platform, consulting contents corresponding to the different stages defined in the course, from which their can be evaluate their knowledge and extract conclusions about the results which must be obtained at the end of each of them. The students' interactions with the virtual agents provide essential information for both teachers and students. Teachers are provided with a feedback about the degree of the student's understanding of the different contents. The interaction with the platform allows students to develop the ability to put concepts into practice, verifying whether their proposed solution is correct or not and also doing this in an innovative environment.

3 Practical Case Study

The *EducAgent* platform started to be implemented at the end of the academic year 2009-2010 for its application in the Computer Science Degree at the Carlos III University of Madrid. The subject Compilers was selected for the elaboration of the different questionnaires for the platform. The methodology defined for the evaluation of this subject emphasizes students' continuous assessment. For the generation of the different questions and practical cases to be included i the platform, we considered the following types of exercises: i) questions concerning theoretical contents as a review of methodologies and concepts; ii) connection with programs (like Flex[2] and Yacc[3]) used to propose practical implementations and provide code execution; iii) practical cases proposed to the student to obtain conclusions about the appropriate processes for resolve specific problems.

A total of 110 questions, practical cases and problems was elaborated for the subject. We evaluate these questions by proposing them to students. It should be emphasized that the total of questions were answered by 89% of students. A 86% percentage of students expressed the usefulness of the provided cases and problems to facilitate the achievement of the objectives of the course, enhance their learning and facilitate knowing the degree of understanding of the different contents.

Figure 2 shows an example of a VoiceXML form for the multimodal presentation of a specific question, collect the student's response and provide it to the Natural Language Understanding Module in the *EducAgent* platform. As it can be seen, each VoiceXML file corresponding to a specific question includes an initial grammar, manages of help events, and deliveries the student's answer to the Language Understanding and Answer Analyzer modules.

Figure 3 shows the composition of a questionnaire with questions related to Lexical Analysis. It can be seen that the different kinds of previously described exercises have been incorporated. For each one of the proposed questions, the system provides a comparison of the student's responses with the solution proposed by the agent, as well as instructions about possible mistakes, important points which must be enhanced, information about typical errors, etc.

[2] http://flex.sourceforge.net/

[3] http://sourceforge.net/projects/byacc/

```
<?xml version="1.0" encoding="UTF-8"?>
<vxml version="2.0" xmlns="http://www.w3.org/2001/vxml"
xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xsi:schemaLocation="http://www.w3.org/2001/vxml
http://www.w3.org/TR/voicexml20/vxml.xsd">
<form id="Lexical Analysis">
<block>Please, answer now the following question.</block>
 <field name="PAL-03">
  <prompt>Do you think that regular expressions can be used
          to recognize tokens? Why?</prompt>
  <grammar src="pal-03.grxml"  type="application/srgs+xml"/>
  <catch event="help">
     You have to explain if it is possible to recognize tokens by means
     of the definition of regular expressions.<reprompt/>
  </catch>
</field>
<submit next="/servlet/analisis/pal" namelist="pal-03"/>
</block>
</form>
</vxml>
```

Fig. 2 Example of a VoiceXML form to generate a specific question in *EducAgent*

The indicators about the operation of the platform that we want obtain at the end of the current academic year include the complete evaluation of the different agents and educational contents for the subject, the evaluation of their reliability and usability, the validation of the acceptation degree of the different contents, and the definition and evaluation of technological parameters associated to the specific operation of each one of the modules in the platform.

We have already completed a preliminary evaluation of the *EducAgent* platform based on questionnaire to assess the students' subjective opinion about the system performance. The questionnaire had 10 questions: i) Q1: *State on a scale from 1 to 5 your previous knowledge about new technologies for information access.*; ii) Q2: *How many times have you used Opera Voice before?*; iii) Q3: *How well did the system understand you?*; iv) Q4: *How well did you understand the messages generated by the system?*; v) Q5: *Was it easy for you to get the requested information?*; vi) Q6: *Was the interaction rate adequate?*; vii) Q7: *Was it easy for you to correct the system errors?*; viii) Q8: *Were you sure about what to say to the system at every moment?*; ix) Q9: *Do you believe the system behaved similarly as a human would do?*; x) Q10: *In general terms, are you satisfied with the EducAgent platform?*.

The possible answers for each one of the questions were the same: *Never*, *Seldom*, *Sometimes*, *Usually*, and *Always*. All the answers were assigned a numeric value between one and five (in the same order as they appear in the questionnaire). Table 1 shows the average, minimal and maximum values for the subjective evaluation carried out by a total of 15 students from one of the groups in the subject.

From the results of the evaluation, it can be observed that students positively evaluates the facility of obtaining the data required to fulfill the complete set of objectives of the proposed in the exercises defined for the subject, the suitability

Fig. 3 Example of a questionnaire created using the *EducAgent* platform (in Spanish)

Table 1 Results of the evaluation of the *EducAgent* platform (1=worst, 5=best evaluation)

	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
Average Value	4.6	2.8	3.6	3.8	3.2	3.1	2.7	2.3	2.4	3.3
Maximum Value	5	3	4	5	5	4	3	3	4	4
Minimal value	4	1	2	3	2	3	2	2	1	3

of the interaction rate during the dialog. The sets of points that they mention to be improved include the correction of system errors and a better clarification of the set of actions expected by the platform at each time.

4 Conclusions

In this paper we have described the main characteristics of a multi-agent platform developed to facilitate autonomous learning and self-assessment for e-learning initiatives. The architecture of the *EducAgent* platform includes advanced conversational agents which facilitate a natural communication with student using different input and output modalities, the generation and presentation of the different contents following these modalities, the automatic analysis of students responses, and the generation of an appropriate feedback which takes into account the comparison between the answer provided by the students and the reference answer detailed by the teacher. We have elaborate a set of contents to evaluate the platform in a specific subject. The results of a preliminary subjective evaluation show the positive acceptation of a set of very important features defined for the platform. We consider that the results obtained at the end of the current academic year from both statistics of the different modules and evaluations provided by students, will be very important for the adaptation of our subjects for the requirements of the EHEA.

Acknowledgments. Funded by projects CICYT TIN2008-06742-C02-02/TSI, CICYT TEC2008-06732-C02-02/TEC, CAM CONTEXTS (S2009/TIC-1485), and DPS2008-07029-C02-02.

References

1. Augusto, J.: Ambient Intelligence: Opportunities and Consequences of its Use in Smart Classrooms. Italics 8(2), 53–63 (2009)
2. Cavazza, M., de la Camara, R.S., Turunen, M.: How Was Your Day? a Companion ECA. In: Proc. of AAMAS 2010 Conference, pp. 1629–1630 (2010)
3. Fryer, L., Carpenter, R.: Bots as Language Learning Tools. Language Learning and Technology. Language Learning and Technology **10**(3), 814 (2006)
4. Griol, D., Hurtado, L., Segarra, E., Sanchis, E.: A Statistical Approach to Spoken Dialog Systems Design and Evaluation. Speech Communication 50(89), 666–682 (2008)
5. Kerly, A., Ellis, R., Bull, S.: Conversational Agents in E-Learning. In: Proc. of AI-2008, pp. 169–182 (2008)
6. McTear, M.F.: Spoken Dialogue Technology: Towards the Conversational User Interface. Springer, Heidelberg (2004)
7. Pon-Barry, H., Schultz, K., Bratt, E.O., Clark, B., Peters, S.: Responding to student uncertainty in spoken tutorial dialogue systems. International Journal of Artificial Intelligence in Education 16, 171–194 (2006)
8. Roda, C., Angehrn, A., Nabeth, T.: Conversational Agents for Advanced Learning: Applications and Research. In: Proc. of BotShow 2001 Conference, p. 17 (2001)
9. Wang, Y., Wang, W., Huang, C.: Enhanced Semantic Question Answering System for e- Learning Environment. In: Proc of AINAW 2007 Conference, pp. 1023–1028 (2007)